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A Systems Approach for the Definition of Lean Workflows in Global Aerospace Manufacturing Companies

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Abstract

The aerospace and defence industry operates in an environment that has many regulatory requirements, driving additional challenges to the already required continuous improvement, global supply chain management and strong competition challenges. In order to deal with all that, these organisations attempt to update and develop new tools and management systems that can support the constantly changing way they do business. Most of them have recognised having too complex processes in order to adapt to that necessity, so they are making an effort to drive business process simplification and optimisation. Digital workflow tools and workflow management systems facilitate achieving business process optimization by partially automating them, but prior to that there is a need to carry out a process simplification and leaning exercise.
Process digitisation is a key component of the digital transformation and therefore workflow technology is recognised by numerous industries as being a crucial part of their strategic development. However the aerospace manufacturing industry lacks research efforts on how to automate their workflows with a prior simplification exercise. This research's aim is the development of a framework for workflows optimisation in global organisations. Therefore, this study focuses on describing this approach, which takes several elements from systems theory, applying several systems thinking principles and tools. It is a systems approach applied to workflow design. It emphases on explaining how to extract a set of lean workflows ready to be automated from an organisation's current processes, activity that requires understanding the bigger picture.

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Keywords: Digital workflows; Workflow management; Complexity management

1. Research background

For worldwide organisations, having facilities in different regions and a global supply chain can lead to local adaptation of business processes and deviation from standards [1]. This is not different in the aerospace manufacturing industry, as each commodity or plant often tries to optimise its business processes or documents to increase the efficiency of a specific plant, at the expense of potentially decreasing the overall organisation's efficiency [2], due to the creation of additional interfaces or duplication of data entry into different forms. This is in addition to having to fulfill all requirements driven by a greatly regulated environment, as it happens with the aerospace and defense industry. Additionally, the nature of the products they manufacture, which require several iterations in design and concurrent processes where possible, adds complexity to their end to end business processes [3]. In order to do better than competition in this context, these companies are trying to drive business process simplification within their businesses. Traditionally, this has been sought by simplifying how each task was undertaken.

Conversely, workflow management focuses on the optimisation of the flow of tasks. It looks at how information, documents and tasks are passed from one organisation member to the next, helping with the optimisation of resource distribution, the integration of the various IT tools used and automating notifications and approval processes in order to reduce waiting times [4].

Workflow management systems enable to achieve this functionality by providing software, IT tools and techniques to support business process automation, but prior to this business process optimization, the process simplification exercise needs to be undertaken, and the aim of this study is to propose a framework for the simplification of business processes in

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global manufacturers, in order to design workflows that are then ready to be automated using a workflow tool [5].

Nomenclature

WfMS	Workflow Management System
FFD	Functional Flow Diagram

2. Scientific research challenge

In order to achieve business process simplification without damaging the performance of specific supply chain units or plants, it is important to achieve middle ground between awareness to local plants contexts and the requirement to reach standardisation of an organisation's processes to a certain level, in order to simplify [6]. To ensure that, the understanding of how the information and data flows in the company, all the business processes and the links between functions, becomes key.

To attain that, it is fundamental that the content and function of every activity in a business process is fully understood and also the relationships between tasks, why are they linked in that specific way and the activity owner [7]. This can be achieved by applying the concept of systems, where each module's purpose needs to be comprehended and the overall context for all of them is fully understood.

By definition, every system has to contain at least two different subsystems and they must be linked [8].

A key element for simplification is the establishment of standard processes [9]. But taking into account the level of variations between business units in this type of organisations, it is clear that a traditional step-by-step or end-to-end linear process that meets the requirements for all plants cannot be achieved by taking compromised solutions that try to merge all these plant specific processes into one overarching process.

Although it is true that a fully defined process with end-to-end visibility of the activities that make up the different involved workflows is needed, given these differences in context for each business the provision of a rigid standard process is considered impractical. There is no single 'correct way' or correct sequence of tasks when performing a business process. They are usually more of a system of interrelated activities, which should not operate discretely.

Another cause for the deviation from standards in these businesses is the lack of visibility of the process that needs to be followed, and some companies have suggested that a good start point would be just providing a graphical overview of the process to the different commodities, in order to increase alignment of processes.

It is due to these two challenges that a new approach for workflow definition, which allows developing standard workflows at least on a high level, becomes apparent. There is a need to model the activities, the linkages and data flows between the different workflows in a way that takes account of the differences between businesses.

In addition, engineers have traditionally tended to fix what is immediately obvious resulting in a shallow understanding, seeing only events rather than behaviors and interactions [10]. There is this tendency to create local solutions that increase the inefficiency of the overall system as they seek to fix symptoms to problems often causing more problems. It is in order to deal with the complexity that it has been chosen systems thinking for this research, to help divide the problem into smaller pieces while keeping a focus on the interactions between these parts and gain a deeper understanding of the underlying problem before attempting to solve it.

3. Systems approach for workflow design

The proposed transformational approach will drive several changes to these organisations, helping with the identification of quick win opportunities for simplification and standardisation of processes, identification of the opportunities to workflow, lean transformation of processes which means in this context driving a simplification in your business processes landscape, work and policies, design for workflow automation and workflow digitisation.

With a carefully defined strategy it is possible to take meaningful steps with focused quick win activities alongside a more strategic long term approach using a modular framework. This approach aims to transform the way aerospace manufacturers define their business processes through the application of lean principles, process and system improvement and digital workflow solutions.

As previously mentioned, these processes involve input of data and information into a range of documents, tools and forms, where data does not create flow resulting in duplication, delays and potential for errors. This proposed approach allows complexity to be dealt with, workflows to be identified, and strategies for improvement to be developed.

On a high level the steps that need to be taken are:

1. Processes scope definition
2. Absorption of related regulatory and mandatory requirements
3. Process mapping activity involving different plants and supply chain units
4. Identification of all invariant functions
5. Development of the functional flow diagrams
6. Extraction of the identified naturally occurring workflows
7. Standardisation of these workflows and simplification
8. Engagement with different business units and pilot implementation
9. Digitisation of the integrated set of workflows.

Fig 1. illustrates how these steps are linked in order to deliver a set of lean digital workflows, taking as input the current processes different plants are following in a defined company.

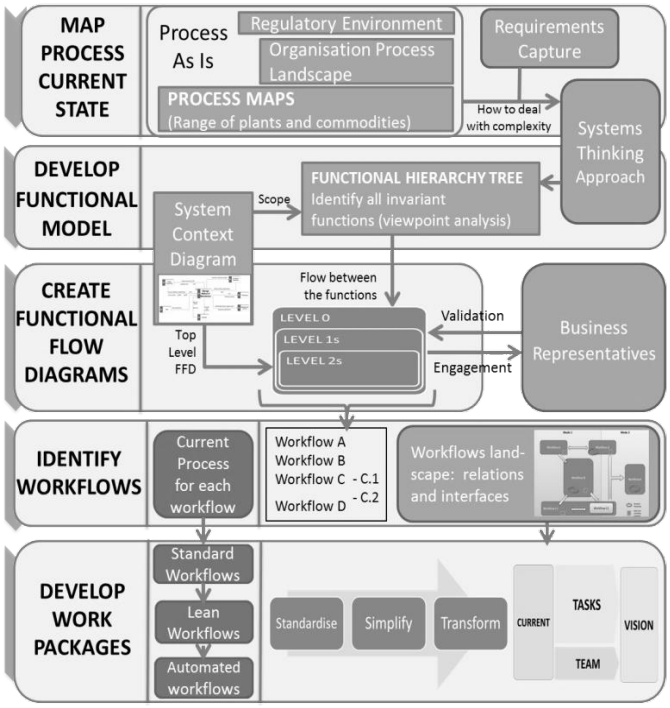

Figure 1: Framework for the identification and optimisation of workflows

Map Process Current State

First of all, the scope of the processes under study needs to be defined. At this point it is helpful to conduct this exercise of process mapping in a phased way, starting with an end to end process and defining its boundaries, so process mapping exercises with the engineering specialists and key stakeholders can be performed.

After the definition of the scope, the next steps that need to be taken are digesting the regulatory and mandatory requirements that affect the processes that will be analysed and mapping the current process in different commodities. These two activities can be carried out in parallel.

The purpose of process mapping is to understand the way the businesses undertake the processes under study. The mapping, when done across multiple areas allows identification of alternate ways of getting things done, inconsistencies and similarities. This discipline puts assumptions aside and deals with what actually happens in a process, not what managers think happens.

To conduct the process mapping activity, this is ideally done through a series of workshops. These workshops involve capturing a global, cross-sector viewpoint of how a process is conducted. A range of facilities have to be visited and the same process has to be mapped. Then these process maps are evaluated to understand current practice.

Usually key conclusions out of this exercise are that the tasks related to one specific end to end process cover a broader scope than initially expected, usually there is a need for some activities to be undertaken concurrently and iteratively which adds intricacy to the process maps, there are differences in approach to the achievement of the required outputs, lack of a defined process that all the businesses are following, significant variation in the configuration of the tasks completed, significant differences in terminology even in cases where the same function is performed and levels of human creativity appearing through the process e.g. process technology choices.

It is likely to happen that different plants will achieve the same output (like a method of manufacture) in different ways. Commodities tend to optimise their own processes, without taking into account the interfaces with other supply chain units or functions. They adapt to their specific environment, sometimes deviating from standards. But, the better a system is adapted to one explicit environment the harder it is to survive when this environment is altered [11].

Instead of attempting to create a consolidated process map out of the different plant specific process maps, which would not show the variations between each of the businesses, it is important to understand why each particular facility carries out the process following a specific order and using bespoke IT tools and software systems. It is likely that during the process mapping activity, the business delegates involved highlight frustrations, concerns, perceived wastes and improvement ideas related to the current process. These have to be documented as requirements for the upcoming set of workflows that will be defined.

Develop Functional Model

Once the set of process maps has been evaluated, the next steps are the identification of the invariant functions and creation of the functional hierarchy tree.

In order to determine the required functionality for the new designed process, fully understand the problem and focus on value add, there is a need to identify the generic system functions that are performed in this specific process, and represent them in a functional hierarchy tree. These functions are described as solution agnostic and enable to understand the way the process works and interacts. Functional modelling addresses the challenge of directly focusing on a solution that could be suboptimal by identifying ‘invariant function’ – the function that will always be performed regardless of the chosen solution of the time.

This functional modelling involves breaking a complex system into functions (subsystems) using a top down approach.

Once all the functions have been identified, next phase is the creation of the functional hierarchy model, which allows getting the functions and sub-functions in the right place relative to each other. One of the key rules for functional modelling is that a sub-function must contribute in some way to delivering the function at a higher level in the hierarchy. The functional hierarchy is a key step on this journey.

Due to the possible large number of activities, documents used and cross functional nature of the work, the system related to an end to end process might be complex, but some functions will be always vital to ensuring quality, safety and performance of their manufacturing products. These functions are usually the ones that would form the highest level of the functional hierarchy tree.

Create Functional Flow Diagrams

Once the hierarchy tree has been created, the links between all these generic system functions – in the case of processes

these are key activities that need to be carried out- need to be captured. This is achieved by developing the so called functional flow diagrams, which help to understand the inter connectivity between the functions, giving visibility of duplication, data flows and critical interfaces. Because the functions described in the model are invariant, they will be 'future proof' and are solution independent. For example, if there is an identified function such as 'approve product design', this function will work as much for a CAD model as a hand drawn sketch. Thus, the functional model may be a platform for future improvement projects, as long as change is managed and model knowledge sustained.

So the linkages between these 'functions' are identified. In context of the end to end process they are the data and information flows. These diagrams illustrate all dependencies and links between functions and activities and through this modelling exercise it is easier to then identify the naturally occurring workflow outlines (boundaries, interfaces, etc.).

It is important that during the process mapping exercise and functional flow diagrams development, these are validated with the business delegates at all times.

Identify Workflows

Out of the functional flow diagrams, it is an upfront exercise the extraction of naturally occurring workflows. Outlining the key workflows identified within the processes on scope delivers a set of standard workflows, that are compliant to all regulatory requirements, and takes best practices from the different plants.

This set of workflows represents what the business is currently doing in a standard and solution independent way. Following, the last step is the development of work packages specific to each of the workflows, to drive their simplification and assess whether digitising them could bring benefit to the company.

Develop Work packages

Therefore, once the standard workflows are identified from the FFD's, taking them from their current status to a simplified and wherever needed digitised future state is done by a series of tailored work packages. The approach proposed for the optimisation of these workflows is shown in Fig 2.

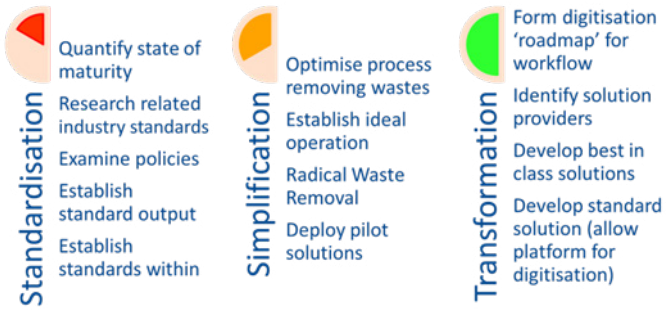

Figure 2: High level approach for the standardisation, simplification and digitisation of workflows

The intention is to propose work packages aligned to this approach, starting with lean transformation activities for each workflow. This will be followed, where appropriate, with a digital workflow solution. The workflow solution may be phased depending on available IT technology and resources. If a fit-for-purpose tactical option can provide a quick win, it should be considered as well.

For each workflow there is a need to identify all opportunities and define a future state workflow. The work packages intent to describe the approach that is recommended to be followed in order to achieve this vision. They clarify the process maturity of each of the workflows, the tasks and deliverables required and the resources needed.

A key component of this framework is the on-going feedback loop that governs each step. Apart from validating each model with the business representatives it is important to define where the vision of the landscape to be achieved is and to know how it will be noticed when the following step has been completed. This is done through the feedback loop illustrated in fig 3, and this step should not be overlooked, as it ensures that the new designed workflow landscape meets all business needs and remains agile.

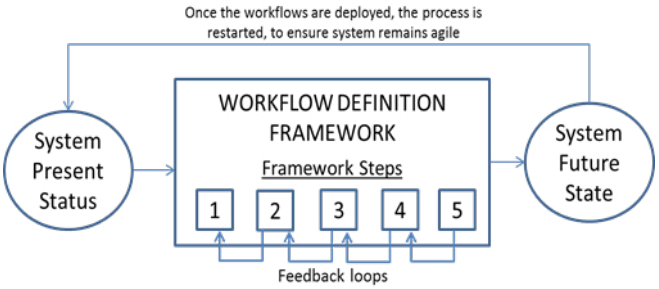

Figure 3: workflow definition framework loop diagram

4. Benefits of the approach

Following this approach brings several benefits to global manufacturers, such as:

- Increasing quality, reducing manual task time and improve flow by eliminating the manual handoffs by automating the work and data flows [12].
- Improving the collaboration between different functions, increasing the understanding of other company functions needs.
- Reducing duplication, rework and change management of the activities to streamline the processes and reduce lead time [13]. Also, it brings and improvement to the productivity as it reduces the administrative work around compliance to processes.
- Increasing the visibility of the end to end process drives accountability, and it focuses on value added elements, improved flow and increased quality of process inputs.
- Removal of local terminology, as applying systems engineering helps to get back to the essence of what is being done.
- The ability to see activities and tasks as sub systems and design them in a way that is in context with the overall process requirements, which may be developed separately but still deliver the overall system requirements.

5. Conclusions

One important aspect is evident from academic research of best practice: process improvement needs to precede digitisation. Digitising a sub-optimal process will result in inefficiencies and problems.

The difficulty when designing a business process or workflow is that those familiar with its current design will think in terms of existing/current 'solution' or 'paradigm'. Systems engineering provides a rigorous approach that deals with complexity (emergent behavior) when developing workflows, and allow to understand the root causes of lack of standardisation by focusing on the bigger picture and the links between functions, rather than just the content of them. The proposed framework helps in bringing an aerospace manufacturer's current process landscape into a set of workflows that are ready to be automated.

Next steps for this research includes the completion of the framework to allow for total capability offering workflows, as focusing only in the process might also develop a sub optimal solution. Ideally the future workflow landscape should achieve total capability, bringing together process, tools, guidance and people.

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